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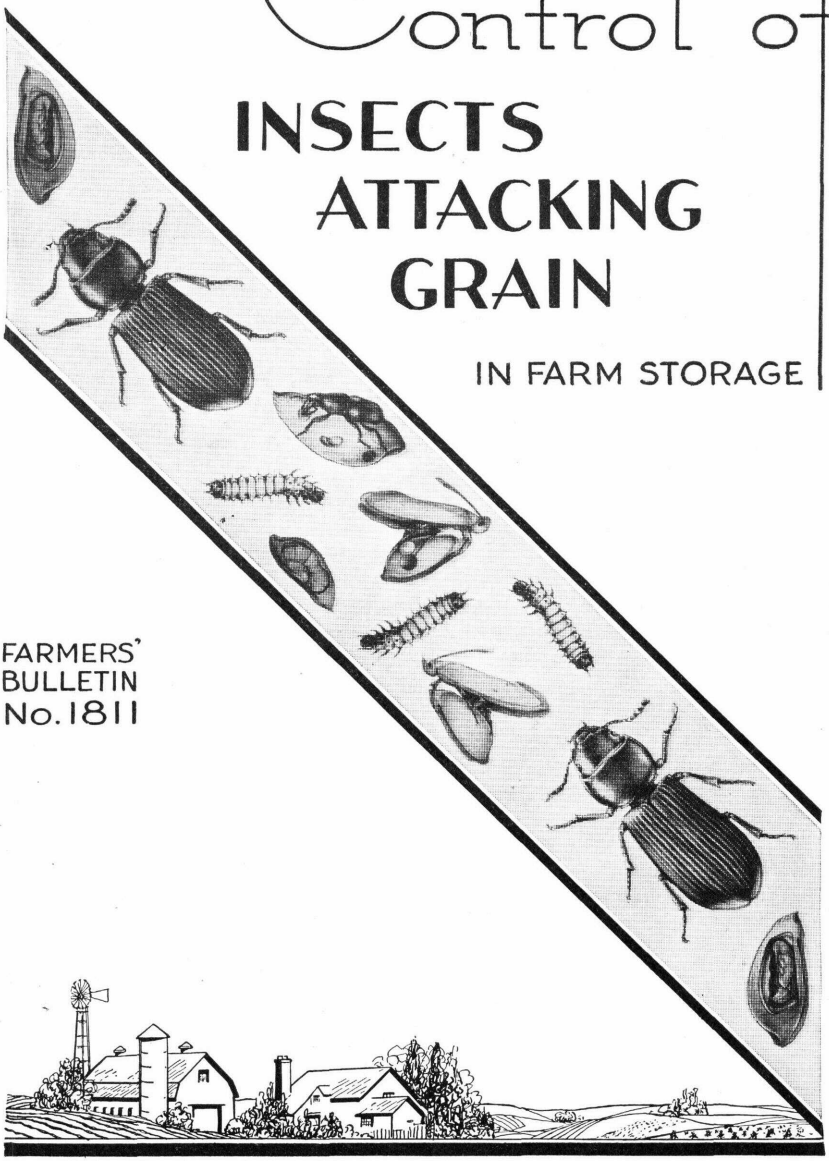
UNITED STATES DEPARTMENT OF AGRICULTURE

Control of INSECTS ATTACKING GRAIN IN FARM STORAGE



FARMERS' BULLETIN No. 1811

IN MANY PARTS of the United States grain cannot safely be stored unless it is properly protected from insects. This protection is so difficult in the South that farm storage of grain is not recommended there.

The insects most injurious to grain in storage are the Angoumois grain moth, the rice weevil, the cadelle, and the several "bran bugs." These are described briefly, and conditions that favor their multiplication are pointed out.

The most common causes of insect damage to grain are failure to clean out the bins thoroughly before they are filled with the new grain and storing near the bins quantities of feed that have been purchased from mills where insects are abundant.

Grain that has become infested with any species of insect should be fumigated as soon as possible. This bulletin tells about the different kinds of fumigants, their cost, and how they should be used.

Washington, D. C. Issued October 1938

CONTROL OF INSECTS ATTACKING GRAIN IN FARM STORAGE

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CONTENTS

NEED FOR SPECIAL PRECAUTION IN PROTECTING FARM-STORED GRAIN

IN MANY GRAIN-GROWING REGIONS of the United States grain cannot be safely stored on the farm unless special precautions are taken to protect it from the ravages of insects. In the South, and in portions of the soft red winter wheat regions of the Central and Eastern States, infestation begins in the field as the ripening wheat and corn are nearing maturity. This initial infestation develops and spreads in the grain after storage until it reaches serious proportions. Unless prompt measures are taken to control it, serious losses result.

In all regions it is customary to store grain year after year in the same bins. If the bins are made of wood, cracks and crevices become filled with grain dust and harbor many insects. Insects such as the cadelle burrow into woodwork to rest and pupate, and later emerge in enormous numbers. Many bins are constructed with an inner lining of tongue-and-groove boards that may not reach to the top, and any space back of them forms a pocket that frequently becomes filled with grain that is difficult to reach and serves as a perpetual breeding place for grain-loving insects. In the rush of harvest it is difficult to find time to clean out these bins, before new grain is stored in them; hence insects in accumulations of old grain and in cracks, crevices, and burrows quickly contaminate the entire new crop.

A common practice on the farm is to store bran, shorts, and other milled feeds in the granary. Occasionally cleanings from flour mills, sweepings, or damaged or infested flour and meal may be purchased

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as cheap sources of feed. These products may harbor such insects as the confused flour beetle, the red flour beetle, the saw-toothed grain beetle, the flat grain beetle, the rust-red grain beetle, and numerous other pests of grain and milled products which sooner or later migrate to the bins of new grain. Such a situation is shown in the accompanying illustration (fig. 1) of a typical barn granary.

THE MORE IMPORTANT INSECTS THAT ATTACK STORED GRAIN

A brief account of the more important insect pests of stored grain and their relation to infestations of grain stored on the farm is given below.

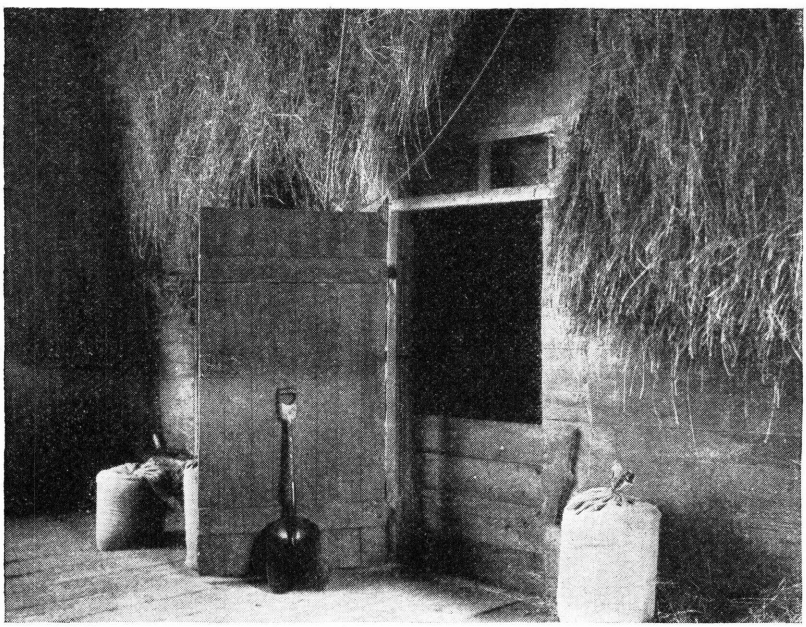

FIGURE 1.—A typical barn granary. Note bags of feed.

THE ANGOUMOIS GRAIN MOTH

The Angoumois grain moth (*Sitotroga cerealella* (Oliv.)) is the moth most commonly found in infested grain. In the South and portions of the soft red winter wheat region of the Eastern and Central States it flies to the fields of ripening corn and wheat as these crops are nearing maturity, and lays eggs upon the wheat heads or corn kernels. These initial infestations take place in the grain when it is in, or passing, the milk stage and usually involve a very small percentage of the kernels. A study of field infestations of wheat in Maryland in 1924 showed an average infestation of 0.26 percent of the kernels at harvest time.

From harvest time until wheat is threshed and stored, however, infestation by the Angoumois grain moth can increase with great rapidity, and in some years infestation of wheat may reach 90 percent by the end of September if threshing is delayed as long as that.

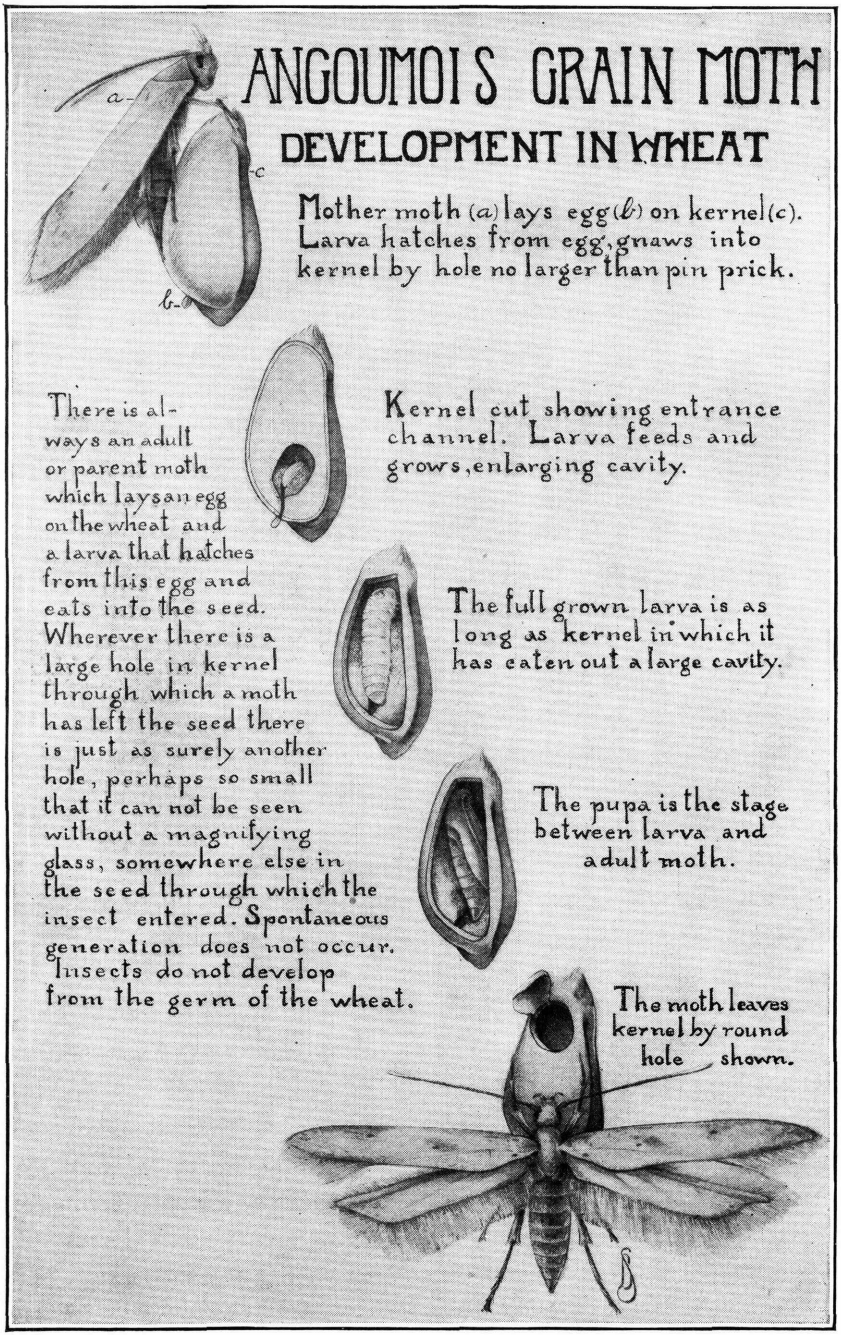

FIGURE 2.—Life cycle of Angoumois grain moth on wheat.

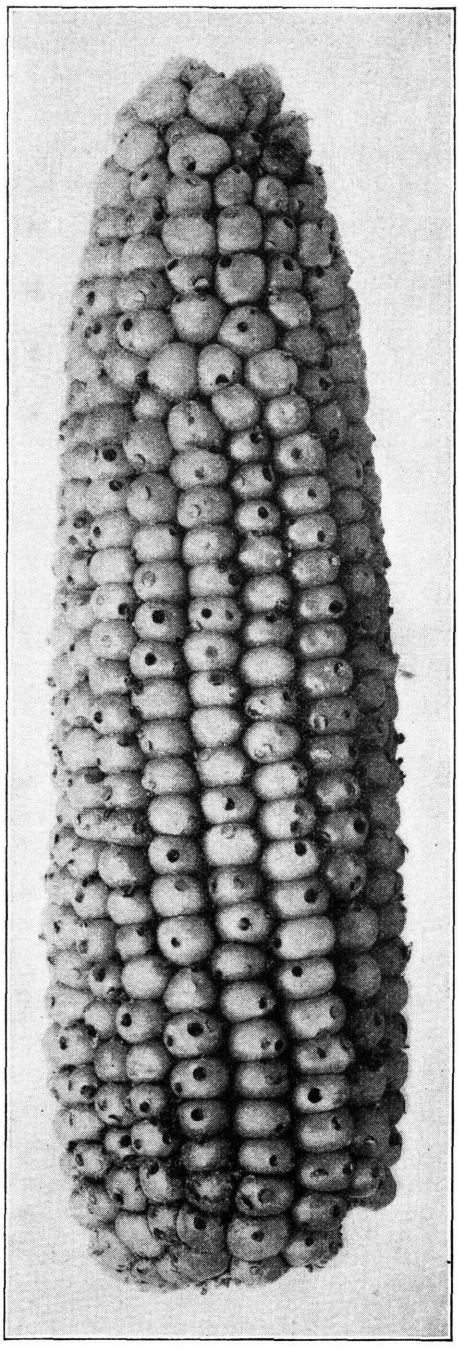

FIGURE 3.—Ear of corn showing emergence holes of the Angoumois grain moth.

When the wheat is in the straw, it is easy for the moths to make their way from one wheat head to another, with the result that infestation is unimpeded; but after the grain is threshed and stored it is impossible for the soft-bodied moths to make their way below the surface of the grain, and infestation is restricted to the surface grain.

Between crops the moths breed in grain in barns, granaries, and corncribs and in waste grain in and around strawstacks.

Each female moth lays, on an average, about 40 eggs, although as many as 389 eggs have been recorded from 1 moth. The eggs, which are laid on or near the grain, hatch into minute white larvae, or caterpillars, that bore into the kernels of grain and begin feeding on the contents. When full-grown, each larva eats out a channel to the outside of the seed but leaves a thin layer of the seed coat intact. It then changes to a reddish-brown pupa, and later the adult or moth emerges, pushing aside the thin section of seed coat that covers the exit from the channel. The development from egg to adult may be completed in 5 weeks. Figure 2 shows the successive stages in the development of this insect in a kernel of wheat from the time the egg is laid until the moth appears. Typical injury to the kernels of an ear of corn are shown in figure 3.

Damage to wheat by the Angoumois grain moth can be largely eliminated by the prompt harvesting and threshing of the crop. Fumigation

after the grain is threshed will then prevent further damage from the initial small infestation that may be present.

In the Northern States, injury by the Angoumois grain moth to corn is not severe except when this crop is stored for more than one season.

THE RICE WEEVIL

The rice or black weevil (*Sitophilus oryzae* (L.)) is the most destructive insect pest of stored grain. It is a small reddish-brown beetle with head prolonged into a long, slender snout, at the end of which are a pair of stout mandibles or jaws. It is further characterized by being marked on the back with four light-reddish or yellowish spots.

The adults fly from granaries or other places containing grain to the fields of corn and wheat in the South and start the infestations

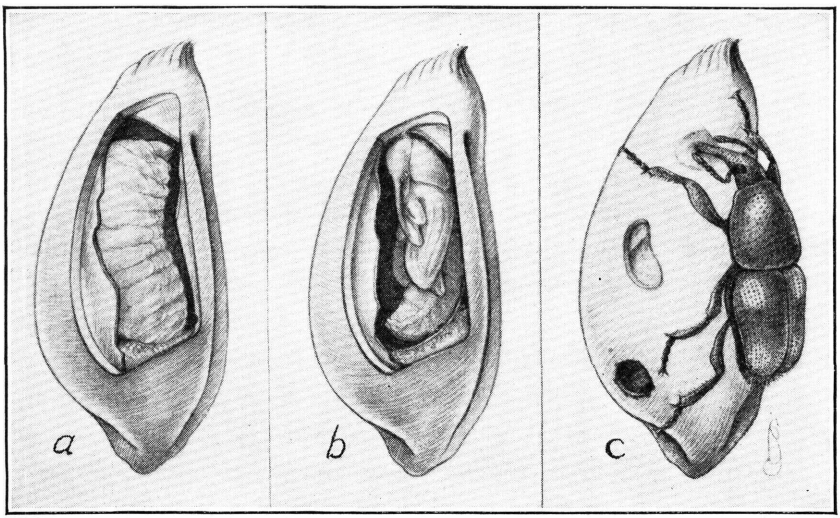

FIGURE 4.—Life stages of the rice or black weevil in wheat: *a*, Well-grown larva; *b*, pupa; *c*, adult feeding upon kernel. Note in *c* the hole in lower portion of kernel made by the adult on having the seed and at two points higher up shallow holes made by the adult in feeding upon the seed after emergence.

that prove so disastrous after the grain has been harvested. In the more northern grain-growing regions this weevil is prevalent in accumulations of old grain in and around granaries, barns, and elevators, and starts infestations in the new grain when it is stored in farm bins or elevators. It is the commonest of the serious pests of commercial grain shipments.

The adult weevil, the full-grown larva or grub, and the pupa are shown in figure 4. Both adults and larvae feed voraciously on a great variety of grains.

The adult weevil lives on an average from 4 to 5 months, each female laying between 300 and 400 eggs during this period. Before laying her eggs, the female bores a small hole in the grain with her mandibles. When this has been made she turns about and lays in it an egg, which she covers with a gelatinous fluid that seals the hole. The small, white fleshy and legless grubs that hatch from the

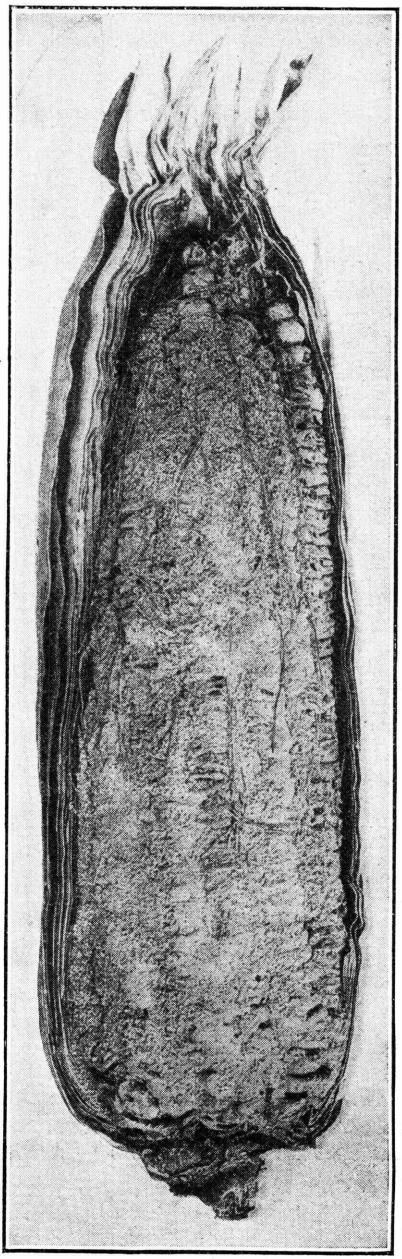

FIGURE 5.—In the South corn is infested by the rice weevil in the field, and unless the corn is fumigated and stored in insect-tight cribs it is soon reduced to the state of the ear shown above.

eggs burrow about inside the kernels and never leave them. When fully grown, these grubs transform to pupae and then to adult weevils, which bore their way out of the grain. During warm summer weather the egg, larval, and pupal stages may be passed in as few as 26 days.

A closely allied species, the granary weevil (*Sitophilus granaria* (L.)), has no wings and cannot infest grain in the field. This insect is usually found in bins and elevators in the Northern States.

The only way to protect grain in the South from damage by the rice weevil (fig. 5) is to fumigate the grain in tight bins immediately after harvest. In the North, infestations by this insect can be largely prevented by storing the grain in bins free from infestation and fumigating it after it is placed in storage.

THE CADELLE

The larvae of the cadelle (*Tenebroides mauritanicus* (L.)) have the unfortunate habit of burrowing in enormous numbers into the woodwork of bins and may remain there for long periods, only to come out when fresh grain is placed in the bin. Many seemingly clean and empty bins may actually harbor thousands of hungry insects, and it is not an uncommon sight to see newly threshed grain literally swarming with worms a few weeks after being placed in wooden bins. Owing to this habit of the larvae of burrowing into woodwork, this insect is one of the commonest pests of grain stored on the farm in all parts of the country. The burrows, which are well illustrated in figure 6, also afford hiding places for many other grain-infesting insects.

The adult cadelle (fig. 7) is an elongate, oblong, and flattened, black beetle about one-third of an inch long. It is one of the longest-lived of the insects that attack stored grain. Many of the adults live

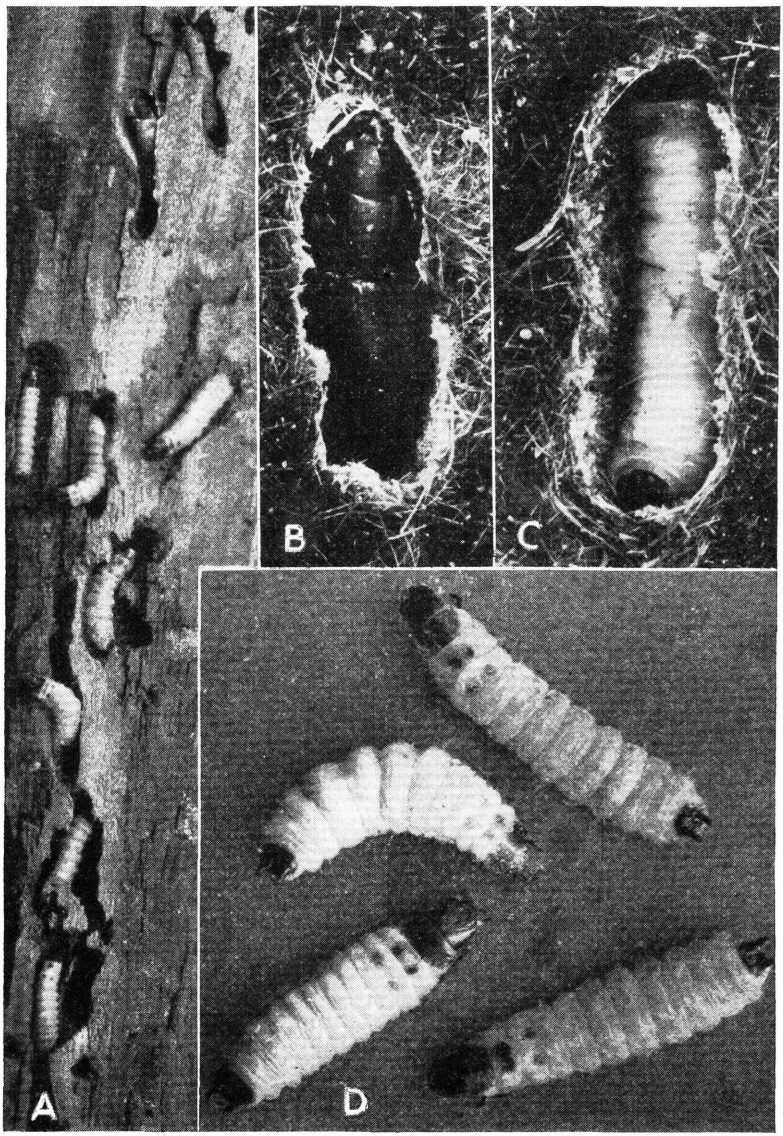

FIGURE 6.—Hibernation of the cadelle: *A*, Sectioned softwood board from granary used for wheat storage, showing numerous larvae of cadelle using board for protection during winter months; *D*, cadelle larvae about to pupate; *C*, cadelle larvae hibernating in pupal chamber; *B*, same as *C*, only several months later, after larva has transformed to adult.

for more than a year and some for nearly 2 years. The females lay about 1,000 eggs each, which hatch in from 7 to 10 days into fleshy,

chalky-white larvae with black heads and 2 horny black points at the end of their bodies. When fully grown the larva is about three-fourths of an inch long. The developmental period from egg to adult may be completed in 70 days under favorable conditions but frequently takes much longer.

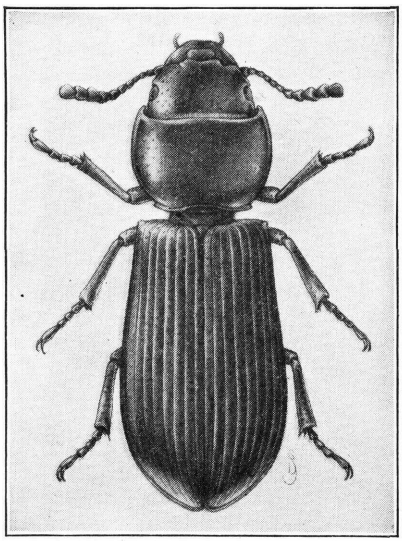

FIGURE 7.—The cadelle, one of the most common pests in in farm-stored grain.

The best insurance against this insect is to clean empty bins thoroughly and fumigate newly stored grain within a few days after it is stored.

"BRAN BUGS"

Several species of beetles that are not primary grain pests but feed on broken grain and grain dust follow up the attack of the true grain beetles and complete the work of destruction. They are referred to by grain inspectors as "bran bugs." These are one-sixteenth to one-seventh inch long and reddish brown in color. The confused flour beetle (*Tribolium confusum* (Jacq.-Duv.) (fig. 8) and the red flour beetle (*T. castaneum* (Hbst.)), which are included in this group, are the worst pests in flour, and their presence in grain constitutes the chief source of infestation in flour mills. The saw-toothed grain beetle (*Oryzaephilus surinamensis* (L.)) (fig. 9) and

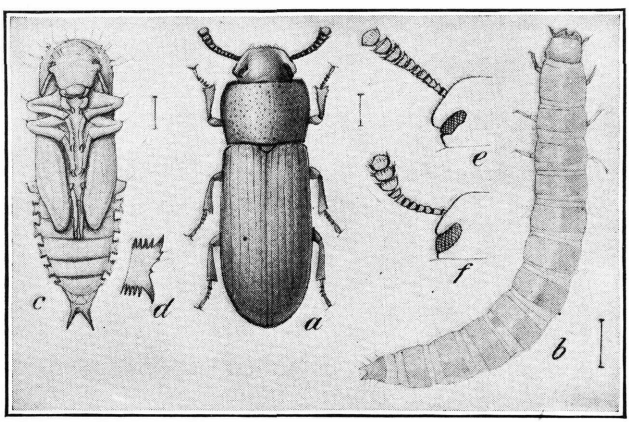

FIGURE 8.—The confused flour beetle, one of the most important of the so-called bran bugs. It is about one-sixth of an inch long. *a*, Beetle; *b*, larva; *c*, pupa; *d*, lateral lobe of abdomen of pupa; *e*, head of beetle, showing antenna; *f*, same of the red flour beetle.

the flat grain beetle (*Laemophloeus minutus* Oliv.) (fig. 10) are other typical examples of bran bugs.

The practice of storing millfeeds, chicken feed, and screenings in or near the granary and failing to clean out accumulations of in-

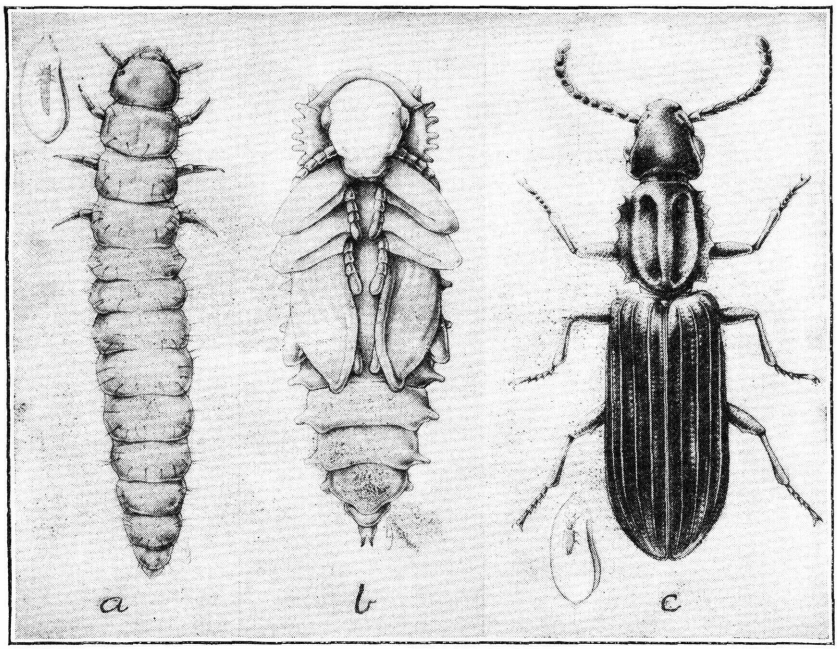

FIGURE 9.—The saw-toothed grain beetle, a frequent inhabitant of stored grain: *a*, Well-grown larva; *b*, pupa; *c*, adult beetle.

fested grain from bins is largely responsible for the infestation of grain by bran bugs. Feeds and screenings are usually infested with insects of this type, and the habit of these insects of migrating when they become abundant, or when they are disturbed, insures the infestation of any nearby grain or cereal product.

Storing grain in bins well removed from all milled feeds, chicken feed, or other cereal products, and cleaning out bins before the storage of grain will do much to prevent infestation by bran bugs.

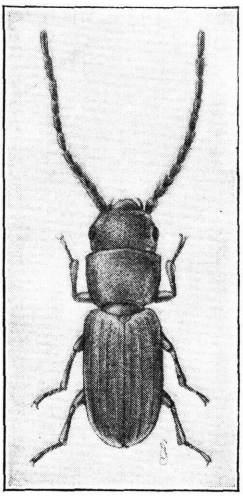

FIGURE 10.—The flat grain beetle, the smallest bran bug found in stored grain, and often more numerous than any other species.

PREVENTIVE MEASURES

Owing to the fact that the insect hazard to farm-stored grain is not the same in all regions (fig. 11), problems pertaining to farm storage of grain in the principal grain-growing regions of the country will be discussed and directions given for treating and handling the grain to prevent or lessen losses from insect attack.

In all parts of the country grain stored for a considerable length of time is subject to injury by insects. To avoid this injury it is necessary to store the grain in tight bins or buildings in which it can be effectively fumigated. The type of construction necessary for

proper fumigation is described in Agricultural Adjustment Administration bulletins, Wheat Storage in the Ever-Normal Granary, and Corn Storage in the Ever-Normal Granary.

GRAIN STORAGE IN REGION 1

Region 1 (fig. 11) comprises for the most part the spring wheat area of the Northern States, the semiarid white wheat area of the Pacific Northwest, and the northern portion of the hard and soft winter wheat areas. In these areas wheat can be stored on the farm with greater freedom from insect damage than in any other section of the country. The chief source of infestation is from insects in accumulations of old grain, in cracks, crevices, and burrows in the woodwork of bins, and from infested millfeed and chicken feed stored on the farm.

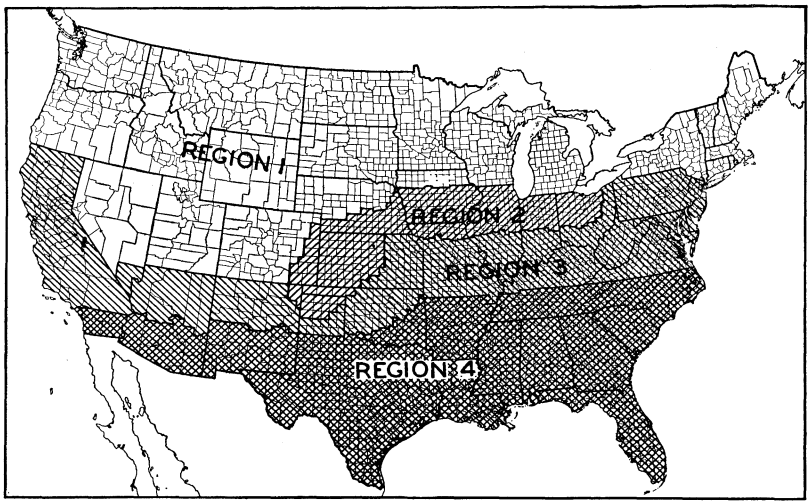

FIGURE 11.—Regional map of the United States, indicating relative hazard to farm-stored grain from insect attack: Region 1, best adapted for safe farm storage; region 2, hazardous for farm storage in some years—frequent inspection and occasional fumigation necessary; region 3, hazardous for farm storage every year—frequent inspection and fumigation necessary; region 4, farm storage unsafe and not recommended—insect control difficult.

Grain-storage structures of all kinds should be thoroughly cleaned, accumulations of old grain removed, and the woodwork sprayed before new grain is stored. Inspection in the fall and subsequent inspections at monthly intervals during the warm weather of the following year are recommended to detect the presence of insect infestations. Grain found infested should be fumigated without delay.

GRAIN STORAGE IN REGION 2

Region 2 (fig. 11) includes the southern portion of the hard winter wheat area of the Great Plains and the northern section of the soft winter wheat area of the Central States. As is the case in region 1, the chief source of infestation is insects in accumulations of old grain in cracks, crevices, and burrows in the woodwork of bins, and infested millfeeds and chicken feed stored on the farm. During seasons of

abundant rainfall, wheat is high in moisture and particularly susceptible to attack, and damage to farm-stored grain in this region may be extensive.

Grain-storage structures of all kinds should be thoroughly cleaned, accumulations of old grain removed and woodwork sprayed before new grain is stored. Monthly inspections of stored grain should be made after harvest until the advent of cold weather. Subsequent inspections at monthly intervals during the warm weather of the following year should also be made to determine the presence of insect infestations. Grain found to be infested should be fumigated without delay.

GRAIN STORAGE IN REGION 3

Region 3 (fig. 11) comprises the central section of the soft red winter wheat area of the Eastern States, the southern portion of the Central States, and the white wheat area of California. The susceptibility of wheat to field infestations of the Angoumois grain moth in the Eastern States makes it necessary to thresh the grain as soon after harvest as the wheat is dry, to insure it against possible severe damage. In the entire region wheat is also highly susceptible to the attack of other insect pests of stored grain; hence it is necessary to fumigate all wheat as soon as possible after it is placed in storage.

In this region, cleaning out the bins before the storage of new grain is essential. The use of a good contact spray that will penetrate cracks and burrows but will not contaminate or impart an odor to the new crop of grain is also recommended. Except during the winter, inspection of stored grain should be made monthly throughout the year. Corn grown in this region is usually stored in slat cribs that cannot be fumigated. The Angoumois grain moth frequently infests corn so stored, but little serious damage is done unless the corn is held over the summer following harvest. If storage of corn for more than one season is contemplated, the corn should be shelled before the end of the first year of storage after the corn has become thoroughly air dry, stored in tight bins, and fumigated.

GRAIN STORAGE IN REGION 4

Region 4 (fig. 11) includes areas in the South and Southeast in which farm storage is extremely hazardous except for short periods. In this region infestation begins in the field and is frequently extensive before grain can be harvested and placed in storage. The warm, humid climate favors rapid multiplication of stored-grain insects, and the chances of sound grain becoming reinfested from outside sources are greater here than elsewhere.

Thoroughly cleaning the bins prior to storage of the new grain is highly important, since old accumulations of grain in this region are invariably infested. If grain is stored, it should be fumigated immediately and monthly inspection made thereafter to determine the presence of infestations. Additional fumigations should be made whenever such infestations are discovered.

FUMIGATION

For treating infested wheat or corn in storage on the farm there is nothing cheaper, more effective, or more readily available than carbon disulphide.

Although the fumes of carbon disulphide are inflammable and explosive when mixed with air in certain proportions, this fumigant can be handled with reasonable safety if the proper precautions are taken. It should not be used to treat bins located in barns where the fire hazard cannot be properly controlled and where a fire or explosion will endanger human life or lead to losses of farm animals, farm equipment, buildings, and stored crops. It is well adapted, however, for the treatment of grain storages that are segregated from other farm buildings. The fumes of this gas are quickly absorbed by the grain after application, and the danger from fire or explosion is not prolonged.

If grain bins are located on farms where the fire hazard cannot be controlled, a mixture of carbon disulphide with carbon tetrachloride or a mixture of ethylene dichloride and carbon tetrachloride should be used. These mixtures do not have the fire hazards of carbon disulphide when used as grain fumigants. They are not so toxic as carbon disulphide alone and must be used in larger quantities, and hence are more expensive.

CARBON DISULPHIDE

Carbon disulphide is a colorless, volatile liquid, which boils at 115° F. On exposure to air it evaporates, forming a heavy vapor that is capable of penetrating through deep bins of grain, and is highly toxic to insects.

It is applied by being sprinkled evenly over the surface of the grain in the bin by means of a watering can or similar device, at the rate of from 1 to 3 gallons per 1,000 bushels, depending upon the temperature of the grain and the tightness of the bin. The cooler the wheat, the larger the dosage required. Fumigations at grain temperatures below 60° F. are not highly effective. The use of a tarpaulin to cover the grain after the fumigant is applied will aid in confining the vapor.

The vapor of carbon disulphide is poisonous to human beings if breathed for an extended period. Exposure to light concentrations may induce a feeling of giddiness, which, however, will quickly pass off when one comes out into the fresh air. Small quantities of carbon disulphide can be handled without danger by the ordinary person, although persons having any heart trouble should take little part in its application.

The vapor of carbon disulphide is very inflammable and explosive. Therefore, fire in any form must not be allowed near a bin or building that is being fumigated with this chemical. It must be remembered that lighted lanterns, cigars, pipes, cigarettes, sparks from electric switches, static or frictional electricity, sparks caused by hammering upon metal, or even hot steam pipes may cause an explosion of carbon disulphide vapor.

Carbon disulphide weighs about 10½ pounds per gallon and ranges in cost from about 6 cents a pound in 500-pound lots to 30 cents a pound in 1-pound lots.

MIXTURES OF CARBON DISULPHIDE WITH OTHER CHEMICALS

Mixtures of carbon disulphide with other chemicals, such as carbon tetrachloride and sulphur dioxide, to reduce the fire hazard are now available commercially at a price of about $2 per gallon f. o. b.

the factory. These mixtures consist of approximately 20 percent of carbon disulphide and 80 percent of carbon tetrachloride, to which may be added a small quantity of sulphur dioxide or other chemicals. When properly made, such mixtures appear to be relatively free from fire hazard. It is not advisable for the layman to attempt the manufacture of such mixture, since the safety from fire hazard of the fumigant is dependent upon its proper preparation. Only such mixtures as are sanctioned by fire-insurance underwriters should be used. The toxicity of carbon tetrachloride to man is about equivalent to that of carbon disulphide.

These mixtures should be used at the rate of from 3 to 5 gallons per 1,000 bushels according to the temperature of the grain and the tightness of the bin, if the results are to be comparable with those obtainable from carbon disulphide alone. The fumigant is applied in the same manner as carbon disulphide, by sprinkling it evenly over the surface of the grain.

ETHYLENE DICHLORIDE–CARBON TETRACHLORIDE MIXTURE

Ethylene dichloride, a recently discovered fumigant, is effective in tight bins at temperatures above 70° F. Since the vapors of ethylene dichloride are slightly inflammable, it is customary to use this fumigant in combination with carbon tetrachloride. A mixture of 3 parts by volume of ethylene dichloride with 1 part of carbon tetrachloride is free from fire hazard under ordinary conditions. It can be used as a substitute for carbon disulphide under circumstances where carbon disulphide cannot safely be used.

Ethylene dichloride is a colorless liquid with an odor similar to that of chloroform. It evaporates slowly when exposed to air, forming a vapor that is heavier than air and that will penetrate grain in a manner similar to carbon disulphide vapor. It has no adverse effect upon the germination of seeds and is not dangerous to handle. It has an anesthetic action when breathed in concentrated form, but unless the fumes are breathed for a protracted period no harmful results need be feared.

In admixture with carbon tetrachloride it should be used at the rate of from 3 to 5 gallons per 1,000 bushels of grain and can be applied in the same manner as carbon disulphide.

It can be purchased in 55-gallon drums at a cost of 6.44 cents per pound delivered.

FUMIGATION OF GRAIN IN SMALL ELEVATORS

In some wheat-growing regions grain is stored on the farm in small elevators that are equipped with machinery for handling grain and transferring it from one bin to another. The bins in such elevators are usually of the open-top crib type and may have a capacity of about 5,000 bushels. Grain stored in such elevators can be treated in a different manner from grain in farm storage that cannot be handled. Fumigants can be applied to the grain while it is being moved from one bin to another, so that the fumigant is well distributed, and there is a choice of chemicals. One of the two most satisfactory grain fumigants under these conditions is a mixture of carbon disulphide, carbon tetrachloride, and sulphur dioxide.

Bins in elevators of this type are usually filled over a period of several days. Fumigation will therefore ordinarily be delayed until a bin is filled.

CARBON DISULPHIDE MIXTURE FOR USE IN FARM ELEVATORS

If the carbon disulphide-carbon tetrachloride-sulphur dioxide mixture is used, it can be applied entirely to the surface of the grain of the filled bin in the same manner recommended for the treatment of smaller farm bins. A dosage of 2 gallons of the mixture per 1,000 bushels of grain is recommended. If the grain is warm, the surface method of application will give satisfactory results. If the grain is cool or cold, better distribution of the fumigant can be obtained by spraying, pouring, or dripping it into the grain stream as the grain is transferred from one bin to another.

SPRAYS

Sprays used in treating empty bins should not be of a type likely to contaminate or impart an odor to the grain that will be placed in storage, otherwise the grain will be classed as "sample grade" on account of the odor. Any odorless, tasteless, water-white petroleum similar to that contained in commercial fly sprays for use in dwellings, to which has been added a small quantity of pyrethrum extract, is satisfactory. Since oil sprays are inflammable, care should be exercised in applying such a spray to prevent fires.

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